

Crash Injuries and SUVs: Michigan Case Presentations

Michigan CIREN Cases

Approximately 220 case analyses completed.

CIREN recruitment criteria:

- Newer vehicles (6 years old or less)

- AIS 3+ injury

- Rollovers excluded

Skewed toward frontal and near side impacts

Car and truck, frontal and side impact cases

Total Cases: 166 cases (129 car, 37 truck)

Truck = SUV + Pickup

America likes things BIG

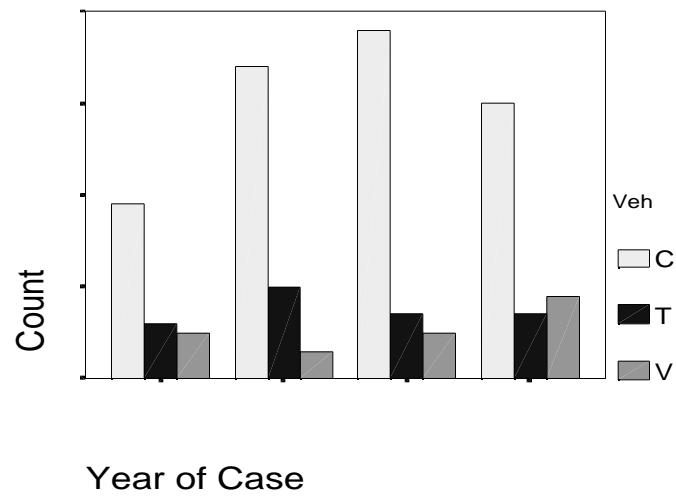


- Big Mac, Big Boy
- Biggie Size, King Size, Super Size
- People are big
- Big wide open spaces
- Big vehicles

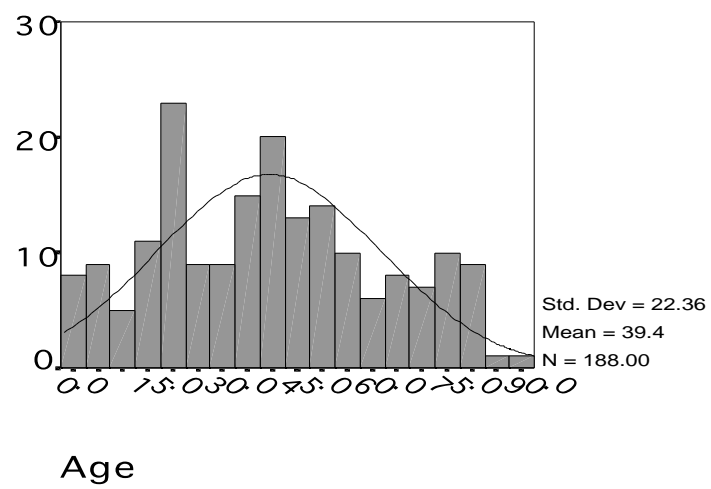


50% of vehicles sold in the USA
are SUVs, light trucks or vans

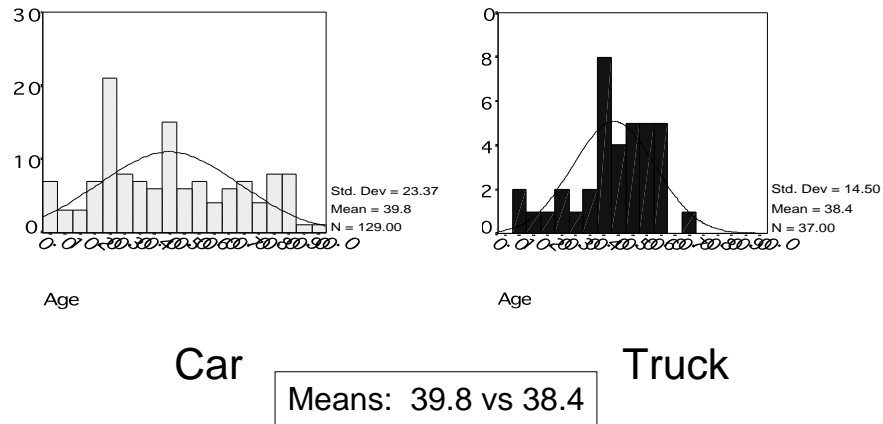
Case Vehicle Type by Year



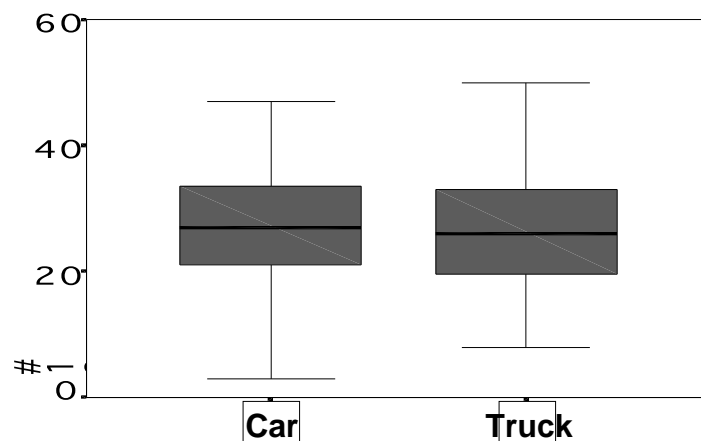
Michigan CIREN Cases



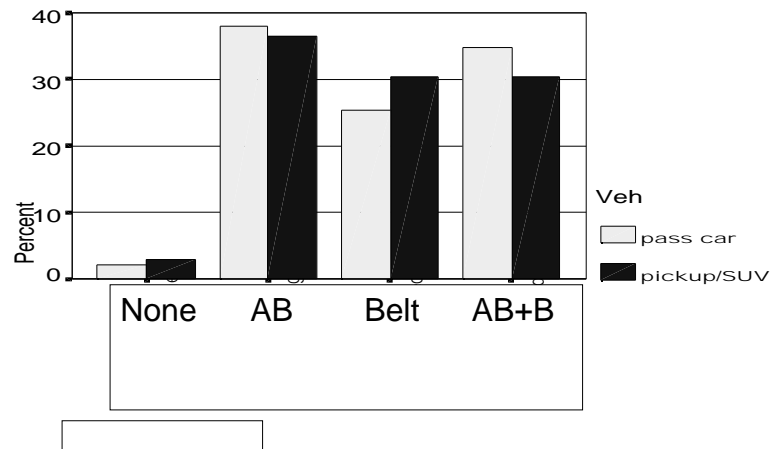
Occupant Age Distribution by Vehicle Type



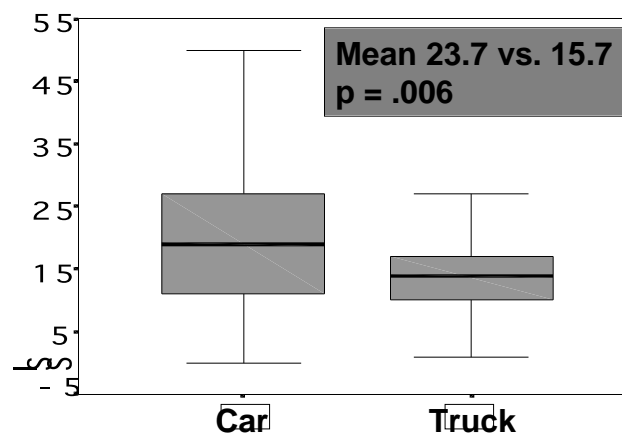
Crash Severity (ΔV MPH) of Car and Truck Cases are Similar



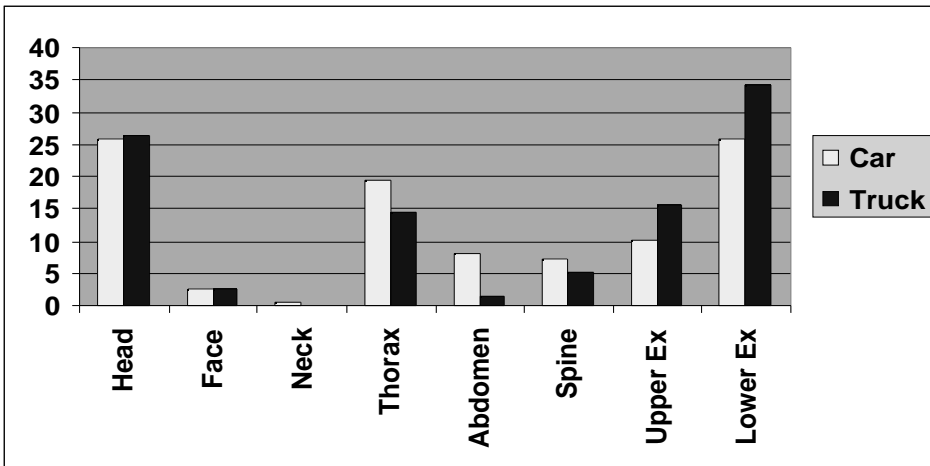
Occupant Restraint Use in Frontal Crashes



Case Occupant Injury Severity Differs Between Cars and Trucks



Relative Body Distribution of AIS 3+ Injuries



Vehicle Differences Mass, Stiffness, Geometry

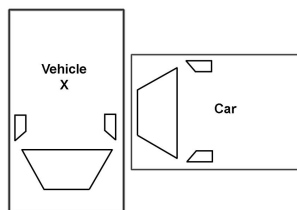


**Mass, Stiffness, Geometry Differences
⇒ Vehicle Incompatibility?**



Ken Campbell & Hans Joksch, UMTRI, 1998

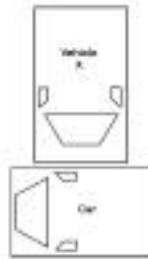
**Fatality Ratios From FARS
Car Front to Vehicle-X Left Side**



Vehicle X	Fatality Ratio (Veh. X/Car)
Car	5.6
SUV	1.4
Van	1.1
Pickup Truck	1.1

Ken Campbell & Hans Joksch, UMTRI, 1998

Fatality Ratios from FARS
Vehicle-X Front to Passenger Car Left Side



Vehicle X	Fatality Ratio (Car/Veh. X)
SUV	30
Van	13
Pickup Truck	25

Ken Campbell & Hans Joksch, UMTRI, 1998

Fatality Ratios from FARS
Vehicle-X Front to Passenger Car Left Side



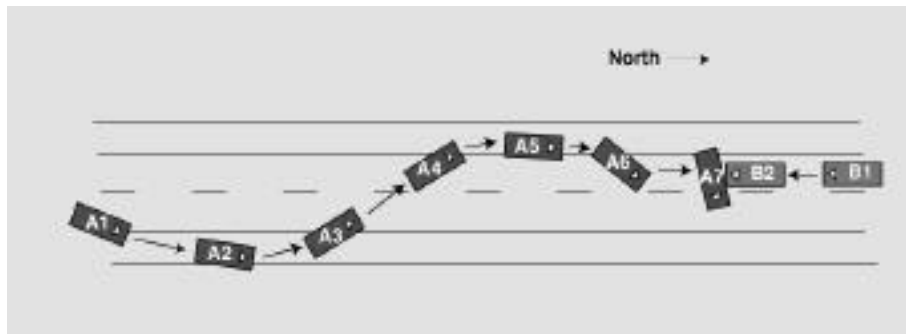
Vehicle X	Fatality Ratio (Car/Veh. X)
SUV	30
Van	13
Pickup Truck	25

5.6 car/car

Truck into Side of Car

Case Example

Crash Scenario



- Case vehicle in red: 1996 Mercedes C220, 4-door sedan (3146 lbs)
- Vehicle B (in blue): 1997 Ford F150, extended cab pickup, 4x2 (4455 lbs)
- Dark, raining, wet concrete
- Driver of V1 ran off right-side of road, oversteered to the left and ran off left-side of road, then oversteered to the right, entered a clockwise yaw, re-entered the roadway and was struck on the left-side doors

Crash Scene
Crash Location



1996 Mercedes C220



CDC: 09-LZAW-4
PDOF: 280 (-80) degrees
DDL: 243 cm
Maximum Crush: 37 cm (estimate)
Crash Severity: 23 mph ΔV

Vehicle (B) - 1997 Ford F150



CDC: 12-FDEW-2
PDOF: 360 degrees
DDL: 180 cm
Maximum Crush: 33 cm
Crash Severity: 17 mph ΔV

Driver sustained police reported "C" injuries

Case Vehicle - 1996 Mercedes C220



**Left B-pillar separated at both top and bottom
LF door hinge and LR latch separated**

Case Vehicle - 1996 Mercedes C220



Sill was partially engaged - late in the crash event

Case Vehicle - 1996 Mercedes C220



Case Vehicle - 1996 Mercedes C220



Head contact - hair transfer on far-side B-pillar and right-rear door lock

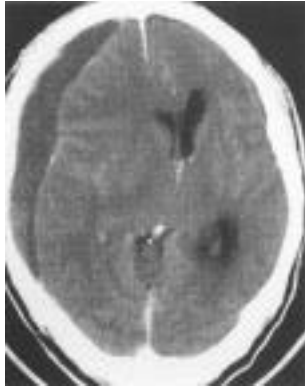
Case A

- **27-year-old female driver**
- **3-point-belt and airbag restrained**
- **Height: 5' 2" (158 cm)**
- **Weight: 180 lbs (82 kg)**

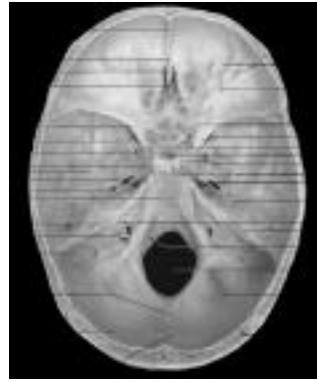
- **ISS: 75**

Medical data slides removed for
confidentiality purposes

Case A - Head Region Injuries



**Subdural Hemorrhage
(example)**



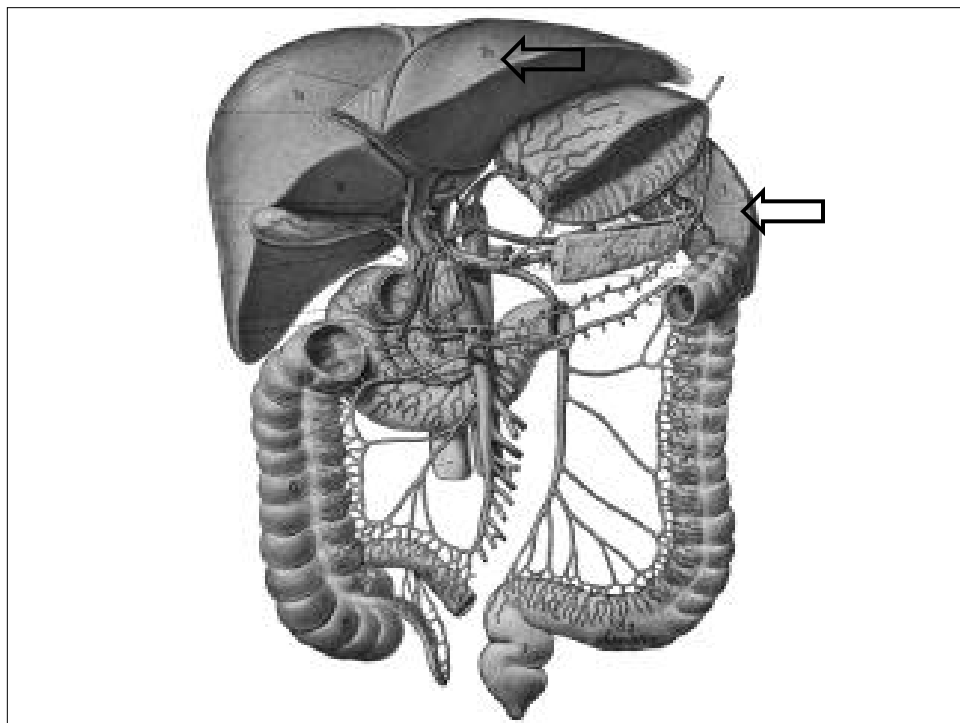
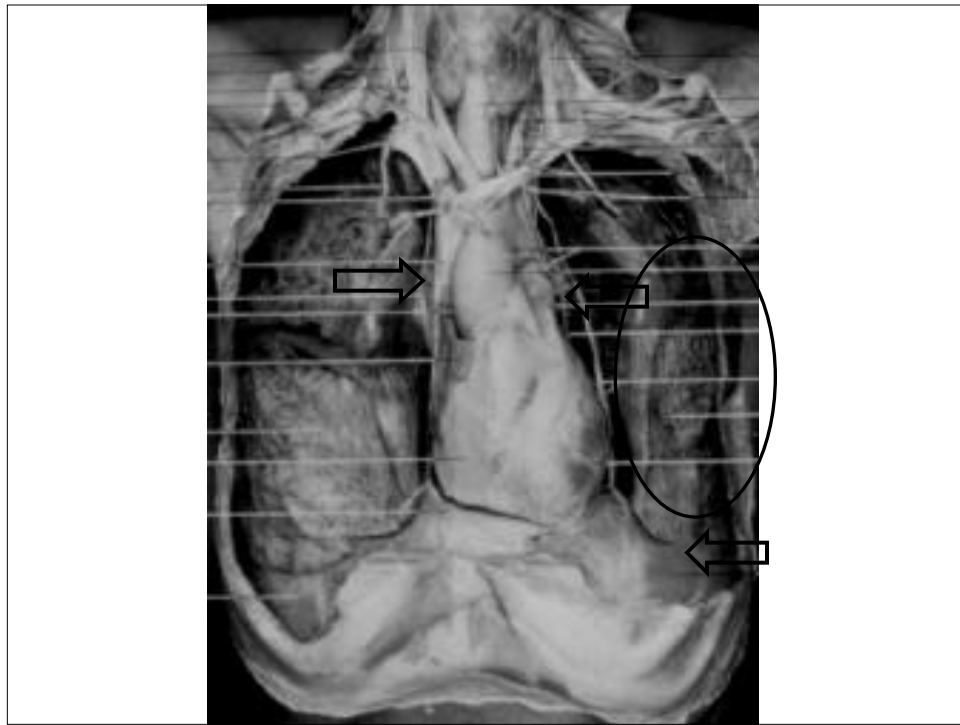
Basilar Skull Fracture

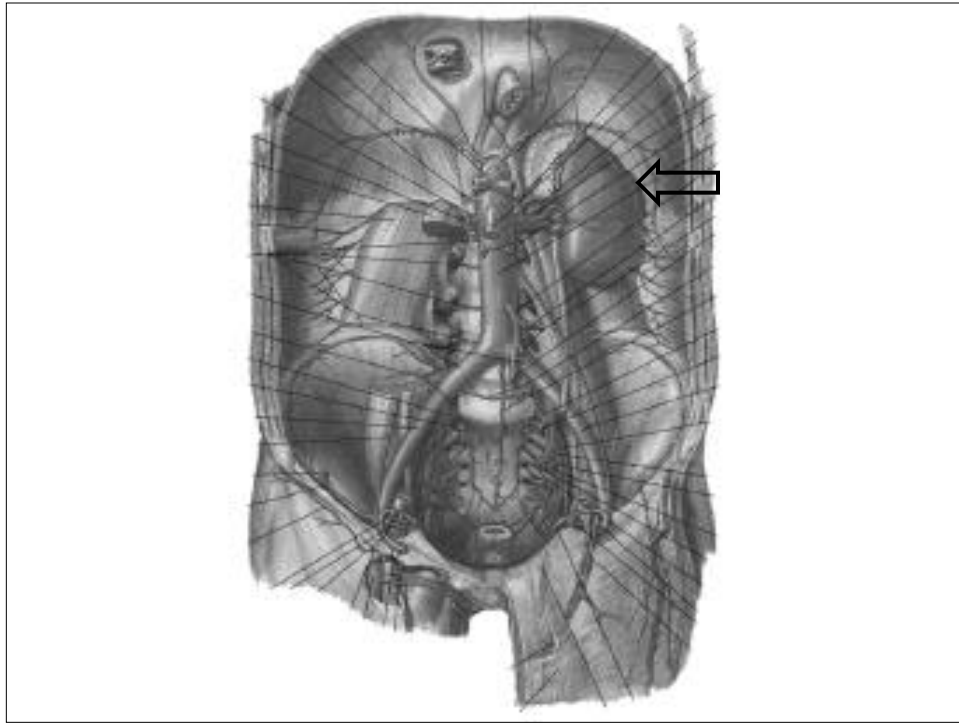
Case A - Neck Region Injuries



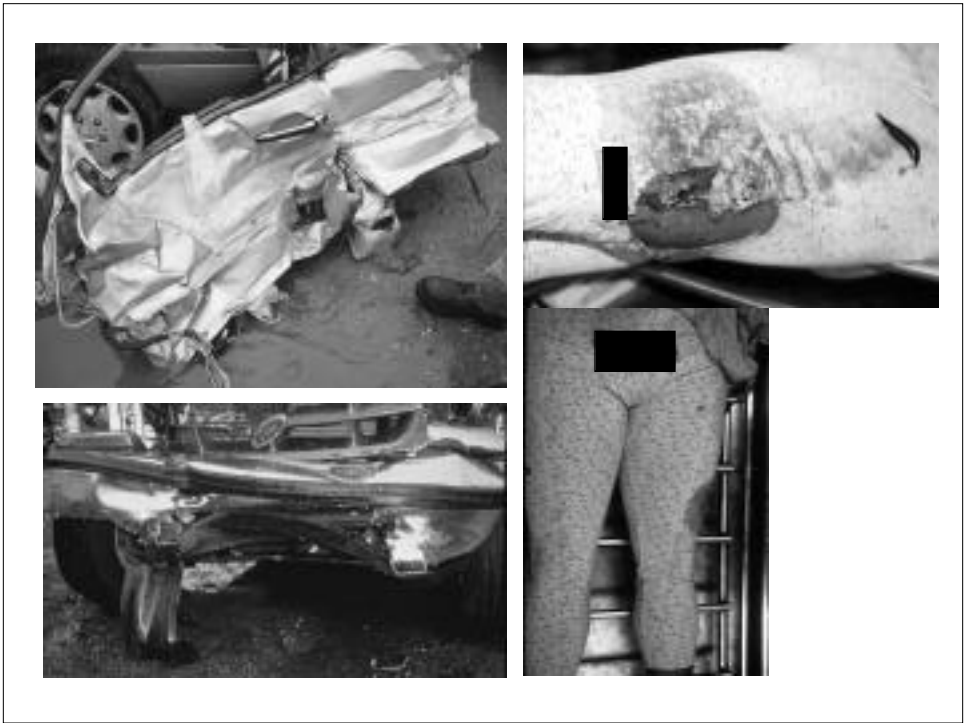
**A-O Dislocation
(Example)**





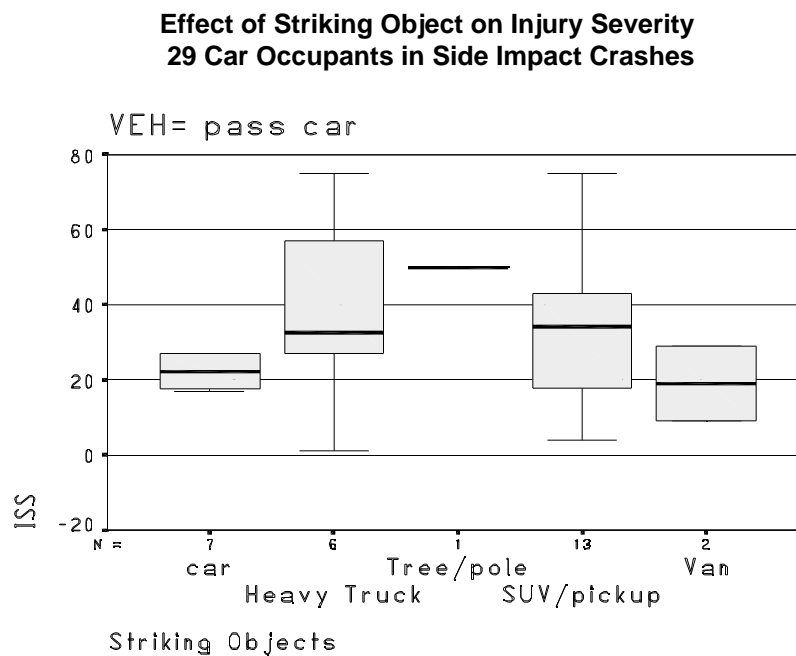


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Case A Observations

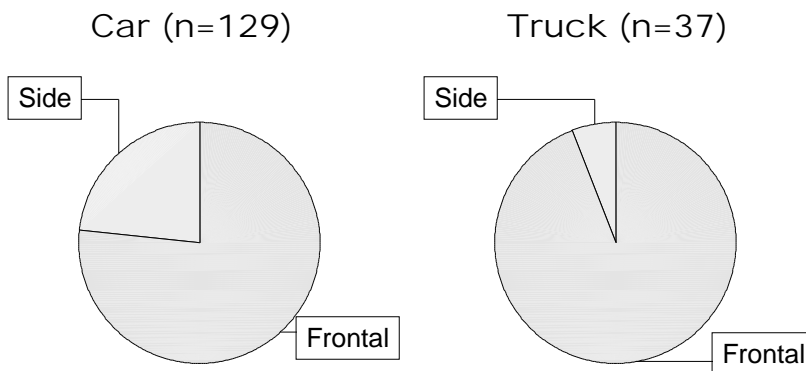
- **Example: occupant of a car hit in the side by a truck.**
- **Multiple fatal injuries to the upper abdomen, chest , neck and head.**
- **Relatively minor injury to the pelvis.**



Car into Side of Truck

Injury Case Example

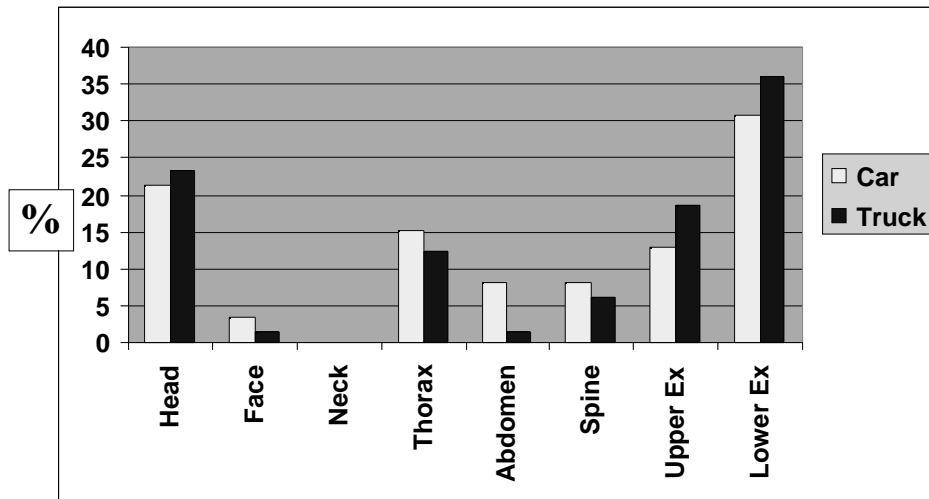
Michigan CIREN Cases (Car/Truck & Side/Frontal)



Frontal Collisions between Trucks and Cars



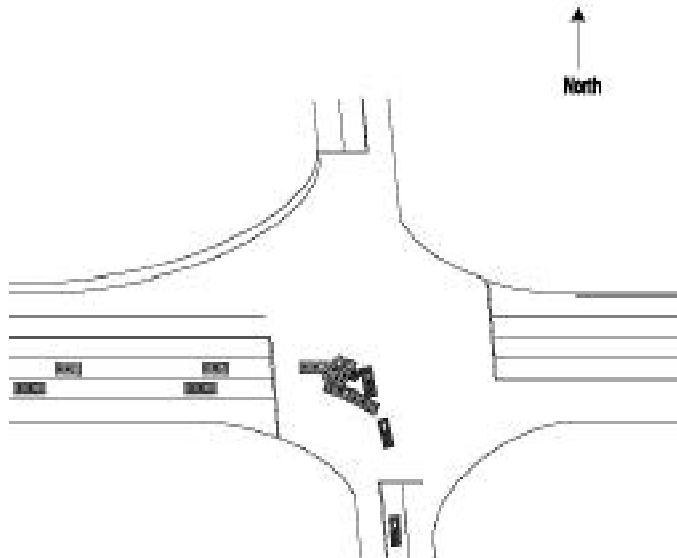
Body Distribution of AIS 3+ Injuries in Frontal Collisions (%)



Front to Front Collision Car versus Truck

Case Example

Crash Scenario



- V1 (red) is a 1998 Pontiac Grand Prix (3410 lb)
- V2 (blue) is a 1998 Dodge Durango (4455 lb)
- Driver of V1 made left turn into the path of V2
- Five occupants of case vehicle (V1)
- One occupant in V2
- Dark, but lighted
- Snowy weather
- Wet asphalt roadway

Crash Scene Path of Case Vehicle



Crash Scene
Path of Case Vehicle



Crash Scene
Path of Vehicle 2



Vehicle 2 - 1998 Dodge Durango

Crush Profile



CDC: 12-FDEW-3

Direct Damage Length = 136 cm

Maximum Crush = 65 cm

81% VOL

PDOF: 10 degrees

Impact Severity:

23 mph total ΔV

-23 mph longitudinal

-4 mph latitudinal

Vehicle 2 - 1998 Dodge Durango

Crush Profile



Case Vehicle - 1998 Pontiac Grand Prix
Crush Profile



CDC: 12-FYEW-3

direct damage length = 128 cm

maximum crush = 74 cm

76% VOL

PDOF: 350 (-10) degrees

Impact Severity:

28 mph total ΔV

-27 mph longitudinal

5 mph latitudinal

Case Vehicle - 1998 Pontiac Grand Prix
Exterior Damage



Left wheelbase reduced 37 cm

Case Vehicle - 1998 Pontiac Grand Prix

Exterior Damage



Right wheelbase extended 15 cm

Case Vehicle - 1998 Pontiac Grand Prix

Front-seat occupants - case occupants

- Driver reported she thought she still had a green light when she made a left turn at a four-leg intersection and was struck by V2. She reported attempting to brake just before impact
- The right-front passenger was reportedly seated with her legs crossed on the seat and leaning slightly forward and to the left at impact

Case Vehicle - 1998 Pontiac Grand Prix

Rear-seat passengers - non-case occupants

- The 17-year-old left-rear passenger was wearing the 3-point belt (MAIS 3, ISS 14)
- The 18-year-old center-rear passenger was not wearing her lap belt and loaded the front center armrest and left-front seatback (MAIS 1, ISS 1)
- The 19-year-old right-rear passenger was not wearing his 3-point belt and loaded the right-front seatback (MAIS 2, ISS 4)

Case Vehicle - 1998 Pontiac Grand Prix
1st Row Interior - Overview

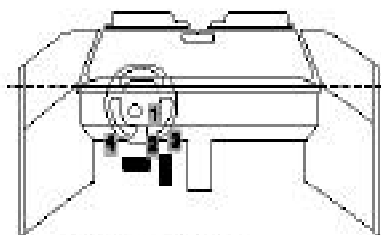


Case Vehicle - 1998 Pontiac Grand Prix

Intrusions

Location	Component	Distance (cm)	Direction
left front	instrument panel	24	to rear
left front	toepan @ left foot	10	to rear
left front	toepan @ right foot	5	to rear
left front	steering column	3	to rear
right front	instrument panel	8	to rear

Case Vehicle - 1998 Pontiac Grand Prix
Occupant Contact Overview



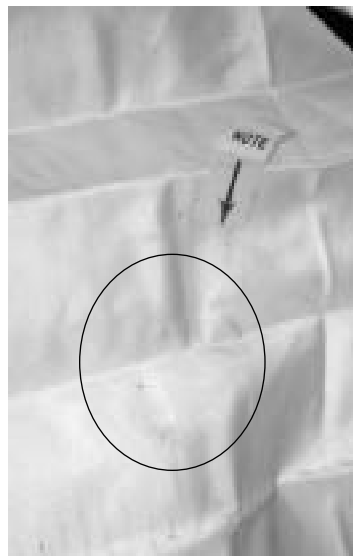
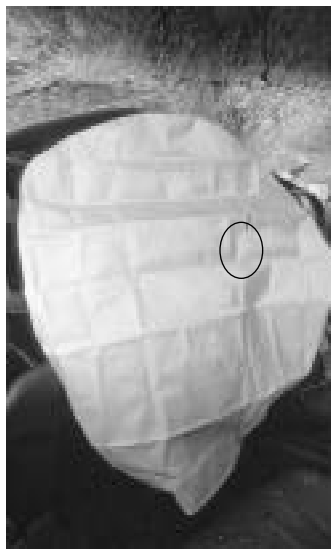
1 in Liquidic transfer on sitting
2 in Slipping forward of the dashboard
3 in Head back
4 in Head back

Case Vehicle - 1998 Pontiac Grand Prix
Driver D-ring



No webbing imprint evident

Case Vehicle - 1998 Pontiac Grand Prix
Driver Contacts



Lip-stick transfer

Case Vehicle - 1998 Pontiac Grand Prix
steering-wheel rim deformation - upper half

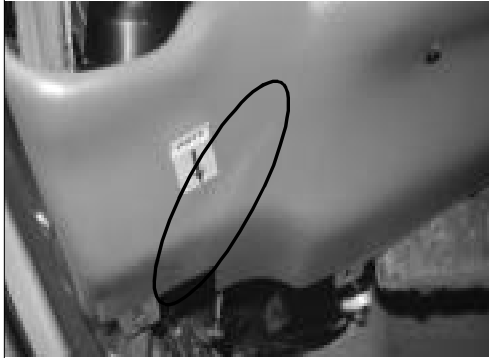


9 cm of forward deflection

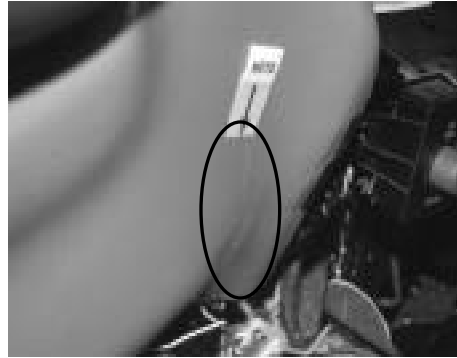
Case Vehicle - 1998 Pontiac Grand Prix
Driver Contacts



Case Vehicle - 1998 Pontiac Grand Prix
Driver Knee Bolster



Left knee strike



Right knee strike

Case Vehicle - 1998 Pontiac Grand Prix
left-front seatback front and back view



loaded by
center-rear
occupant

Case B

- **17-year-old female driver**
- **Airbag restrained**
- **Height: 5' 7" (170 cm)**
- **Weight: 150 lbs (69 kg)**

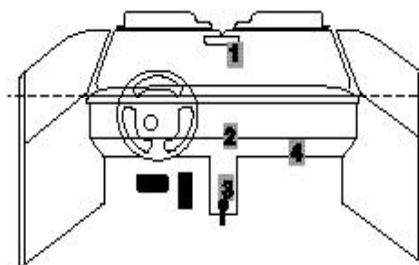
- **ISS: 13**

Medical data slides removed for
confidentiality purposes

Case B Observations

- Depowered-airbag success story for unbelted driver
- Absence of serious head/face, chest or abdominal injuries is noteworthy given the offset nature of the impact and movement of the occupant in the vehicle

Case Vehicle - 1998 Pontiac Grand Prix
Occupant Contact Overview



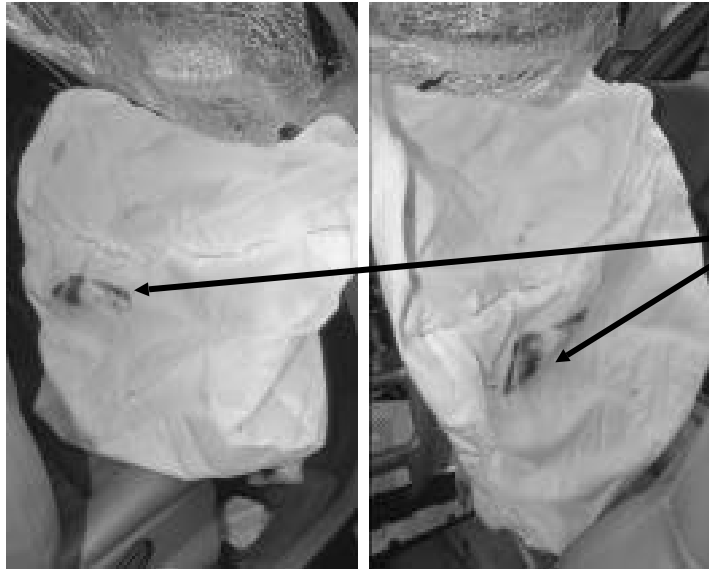
- 1 = Mirror dislocated
- 2 = Rigde and silence control dislocated
- 3 = Scuff mark
- 4 = Blood on airbag

Case Vehicle - 1998 Pontiac Grand Prix
Right-front Passenger D-ring



No webbing imprint evident

Case Vehicle - 1998 Pontiac Grand Prix
Passenger airbag

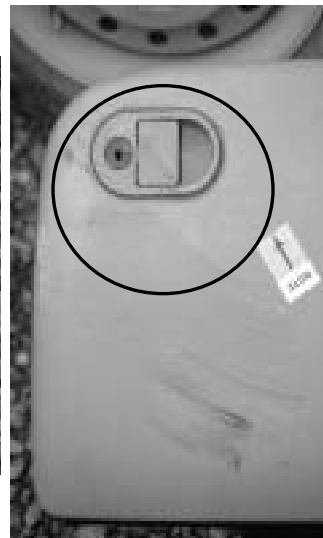


Blood

Case Vehicle - 1998 Pontiac Grand Prix



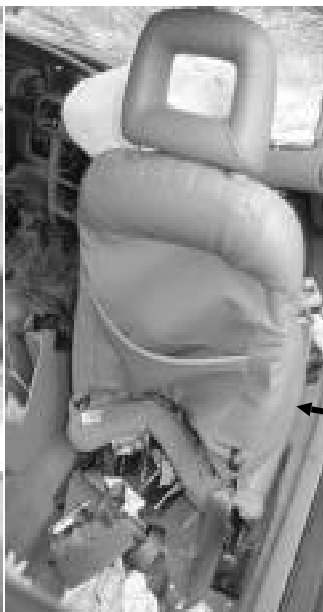
Case Vehicle - 1998 Pontiac Grand Prix
Glovebox Door



Case Vehicle - 1998 Pontiac Grand Prix
Gear Selector



Case Vehicle - 1998 Pontiac Grand Prix
right-front seatback front view



loaded by right-rear
occupant

Case C

- **17-year-old female right front passenger**
- **Airbag restrained**
- **Height: 5' 1" (155 cm)**
- **Weight: 110 lb (50 kg)**

- **ISS: 24**

Medical data slides removed for
confidentiality purposes

Case C Observations

- Patient was out-of-position at the time of the crash.
- She missed or rolled off the airbag and struck the center instrument panel, causing her most significant injury.
- Given offset nature of crash to driver's side she should have done as well or better than the driver had she been belted or in position.

Vehicle 2 - 1998 Dodge Durango



CDC: 12-FDEW-3

Direct Damage Length = 136 cm

Maximum Crush = 65 cm

81% VOL

PDOF: 10 degrees

Impact Severity:

23 mph total ΔV

-23 mph longitudinal

-4 mph latitudinal

Case Vehicle - 1998 Dodge Durango



Case Vehicle - 1998 Dodge Durango

- Driver reported she did not have time to attempt avoiding the collision
- Driver reported her hands at the 10 and 2 o'clock positions on the steering wheel and her right foot on the accelerator and left foot on the floor at the time of impact

Case Vehicle - 1998 Dodge Durango
Driver D-ring



Webbing imprint evident

Case Vehicle - 1998 Dodge Durango
1st Row Interior - Overview of IP and Above

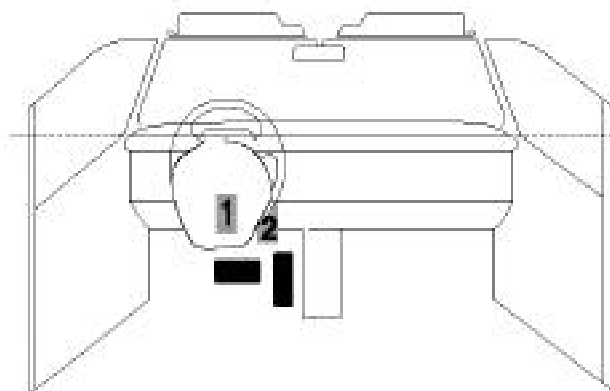


Driver toepan sustained 7 cm of rearward intrusion

Case Vehicle - 1998 Dodge Durango
1st Row Interior - Overview

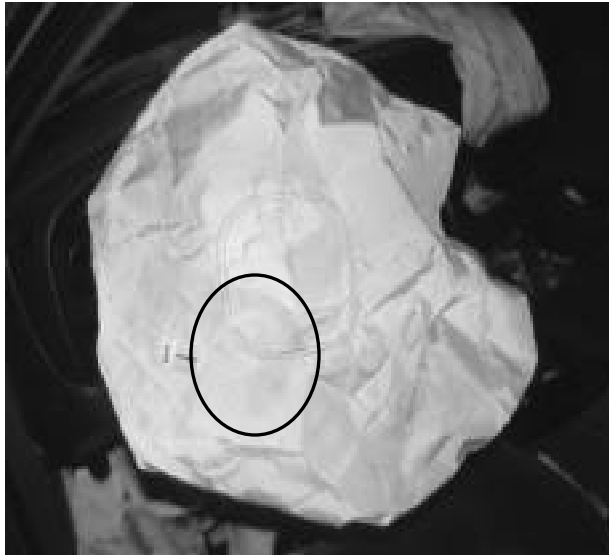


Case Vehicle - 1998 Dodge Durango
Occupant Contact Overview



1 = Make-up transfer
2 = Scuff mark

Case Vehicle - 1998 Dodge Durango
Driver Contacts



Make-up transfer

Case Vehicle - 1998 Dodge Durango
Driver Knee Bolster



Right knee strike

Case D

- **25-year-old female driver**
- **3-point-belt and airbag restrained**
- **Height: 5' 3" (160 cm)**
- **Weight: 118 (54 kg)**

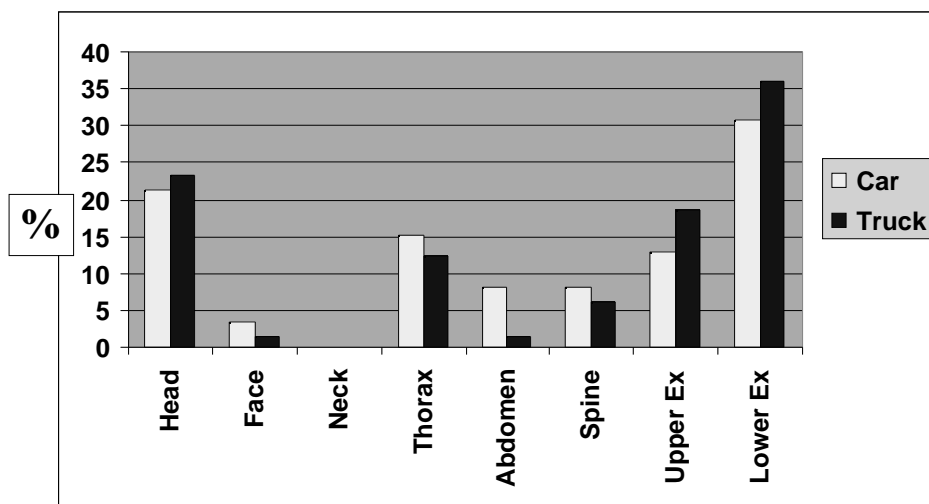
- **ISS: 10**

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confidentiality purposes

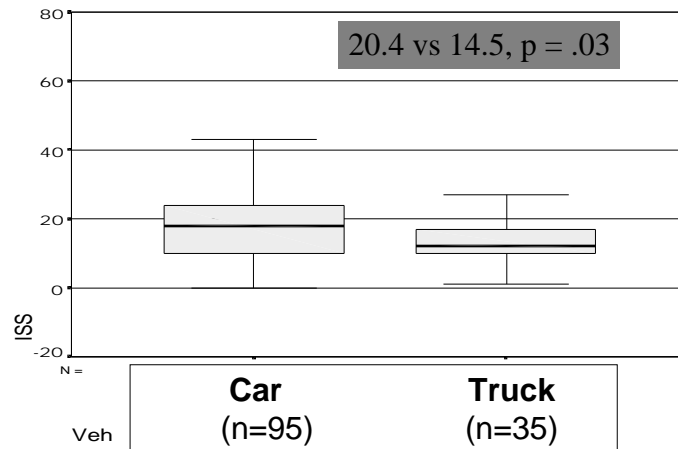
Case D Observations

- **Seatbelt and airbag success story for a pregnant driver**
- **No fetal complications in this severe frontal impact**
- **Significant injuries to the lower extremities only and in the absence of gross intrusion**

Body Distribution of AIS 3+ Injuries in Frontal Collisions (%)

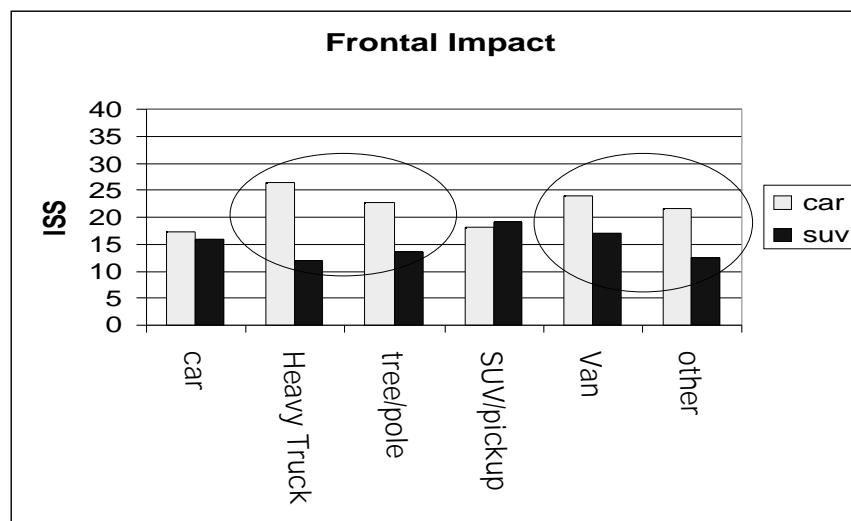


ISS in Frontal Collisions Comparing Car and Truck



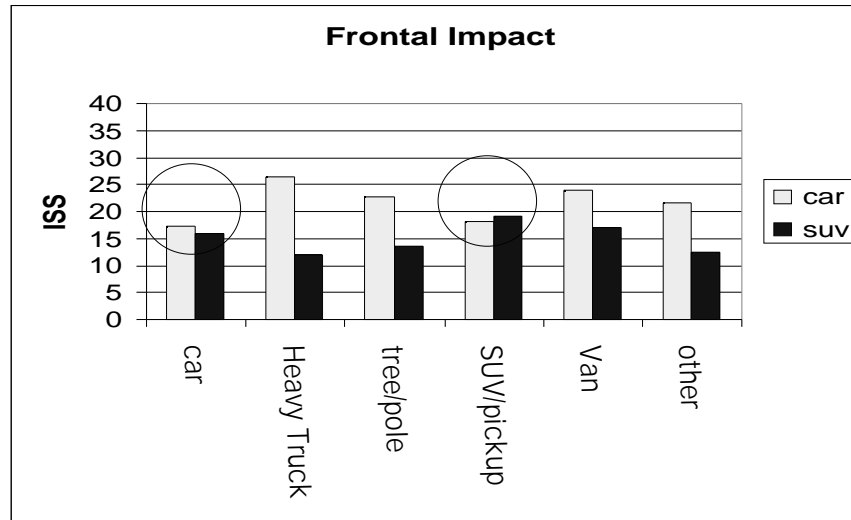
The Object Stuck Affects Injury Severity in Car and Truck Frontal Crashes

n= 130

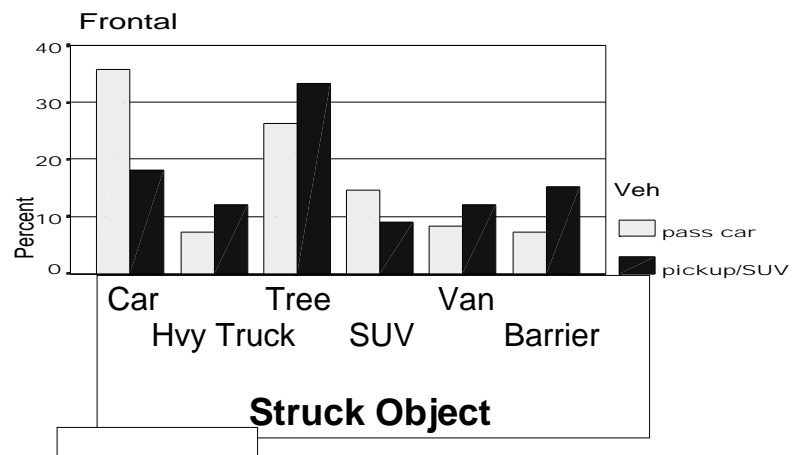


The Object Struck Affects Injury Severity in Car and Truck Frontal Crashes

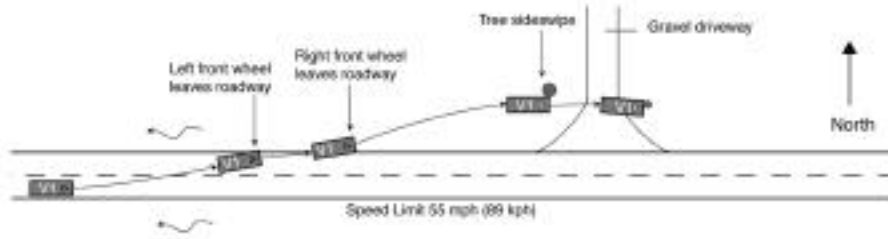
n= 130



Distribution of Objects Struck in Frontal Collision cases



Crash Scenario



- Case vehicle in red (V1): 1997 Chevrolet C1500 pickup
- Daylight, cloudy, dry, asphalt
- Driver of V1 leaned over to pick up cell phone that had fallen on floor, RF passenger reached over to steer vehicle after it had left the roadway. V1 sideswiped tree with left-front fender then struck a second tree head-on with left-front bumper

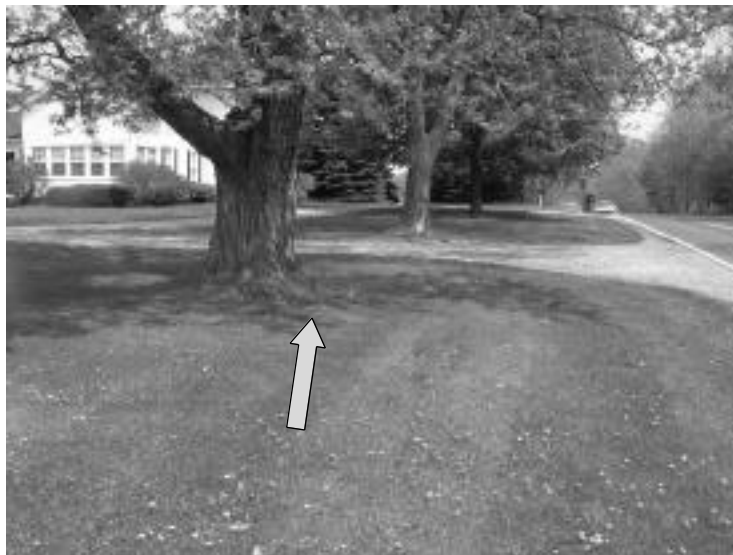
Crash Scene Case Vehicle Approach



Crash Scene
Path of Case Vehicle



Crash Scene
Path of V1



Crash Scene
Path of V1



Crash Scene
Path of V1



Case Vehicle - 1997 Chevrolet C1500 pickup
Exterior Damage - Overview



- 1st CDC: 11-LFES-1 (sideswipe)
- PDOF = 350 degrees
- 2nd CDC: 12-FYEW-3
- PDOF = 00
- direct damage = 62 cm
- maximum crush = 59 cm
- offset-frontal, 41% VOL
- 36 mph ΔV

Case Vehicle - 1997 Chevrolet C1500 pickup
Exterior Damage



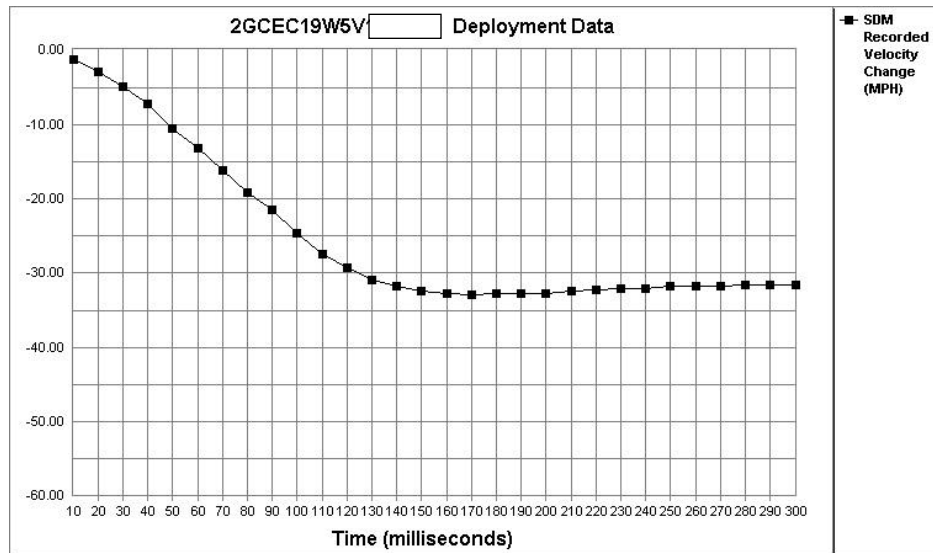
Left wheelbase reduced 24 cm

Case Vehicle - 1997 Chevrolet C1500 pickup
Exterior Damage



Right wheelbase increased 7 cm

1997 Chevrolet C1500



1997 Chevrolet C1500

26CFC1997 System Status At Deployment	
Off-Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	ON
Ignition Cycles At Deployment	9090
Ignition Cycles At Investigation	9092
Time From Algorithm Enable To Deployment Command (msec)	11.26
Time From Air Deployment To Deployment (msec)	38

Time (milliseconds)	18	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (ΔFt)	-1.22	-3.87	-4.83	-7.24	-10.53	-13.18	-16.24	-18.89	-21.90	-24.57	-27.43	-29.16	-30.94	-31.81	-32.47
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (ΔFt)	-32.65	-32.91	-32.69	-32.68	-32.68	-32.47	-32.25	-32.83	-32.83	-31.81	-31.81	-31.61	-31.50	-31.58	-31.58

Case Vehicle - 1997 Chevrolet C1500 pickup
1st Row Interior Overview



Case Vehicle - 1997 Chevrolet C1500 pickup
Intrusions



Instrument panel far left = 7 cm

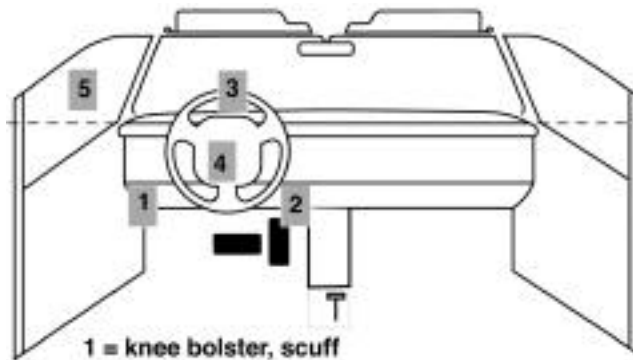
Toe pan at gas pedal = 20 cm

Toe pan at brake pedal = 20 cm

Case Vehicle - 1997 Chevrolet C1500 pickup
Driver D-ring



Case Occupant E Possible Driver Contacts

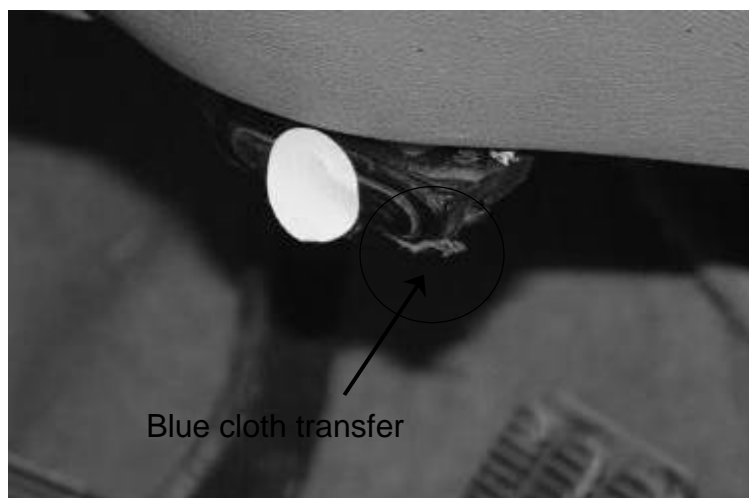


- 1 = knee bolster, scuff
- 2 = utility outlet, cloth transfer
- 3 = SW rim, deformed
- 4 = left airbag flap, cloth transfer
- 5 = left-front window, broken

Case Occupant E Driver Knee Bolster



Case Occupant E
Driver Contact - Right Knee Bolster



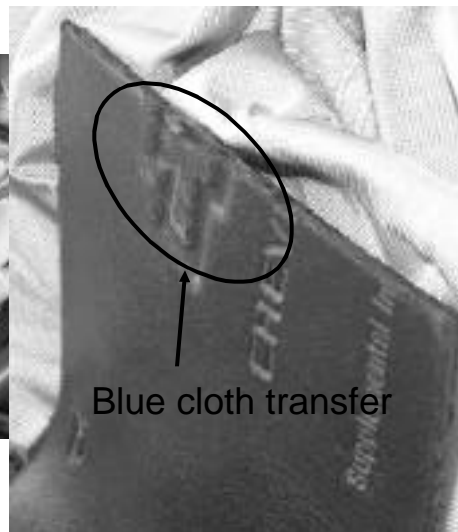
Case Vehicle - 1997 Chevrolet C1500 pickup
Steering Wheel Rim



Case Vehicle - 1997 Chevrolet C1500 pickup
Lower Steering-Wheel Rim Deformation



Case Vehicle - 1997 Chevrolet C1500 pickup
Airbag flap



Case Vehicle - 1997 Chevrolet C1500 pickup
Left-front door glass w/ add-on tinting



Case Occupant
Driver Airbag with Blood Transfers



Blood stains on lower-right quadrant, both front and rear sides

Case E

- **40-year-old male driver**
- **Airbag restrained**
- **Height: 6' (183 cm)**
- **Weight: 260 lb (118 kg)**

- **ISS: 1**

Medical data slides removed for
confidentiality purposes

Case Vehicle - 1997 Chevrolet C1500 pickup
Right-front Passenger D-ring



Case Vehicle - 1997 Chevrolet C1500 pickup
Non-deployed RF Airbag - Switch Off



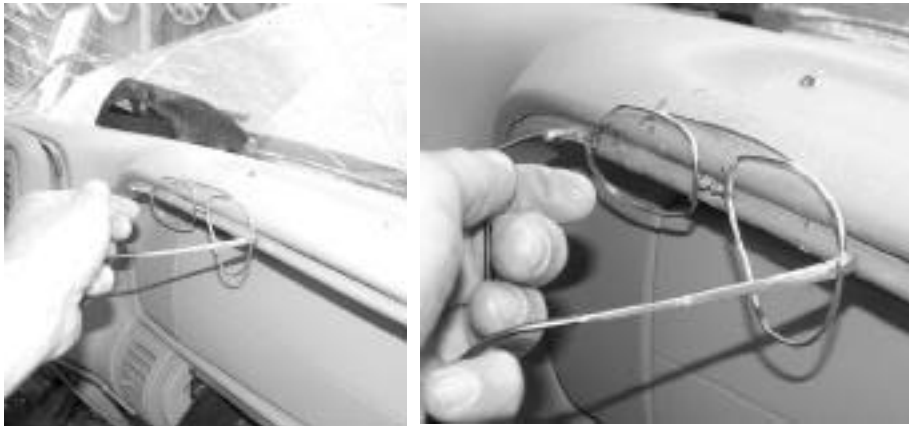
Case Vehicle - 1997 Chevrolet C1500 pickup
Right-front Seating Area Overview



Case Vehicle - 1997 Chevrolet C1500 pickup
Airbag Module Flap - RF Airbag



Case Vehicle - 1997 Chevrolet C1500 pickup
Right-front glasses



Case Vehicle - 1997 Chevrolet C1500 pickup
Right front upper instrument panel



**Case Vehicle - 1997 Chevrolet C1500 pickup
glove box door**



**Case Vehicle - 1997 Chevrolet C1500 pickup
RF Contact - Center IP - Ashtray**



Case F

- **47-year-old male right front passenger**
- **Passenger airbag turned off**
- **Height: 6' (183 cm)**
- **Weight: 165 lb (75 kg)**

- **ISS: 13**

Medical data slides removed for
confidentiality purposes

Case F Observations

- **Passenger airbag turned off.**
- **Occupant unbelted and out of position.**
- **Face excellent impact attenuator.**

Summary

- **Ratio of Car Case Occupants to Truck Case Occupants in Michigan CIREN is 3.5 to 1**
- **Truck side impact cases are rare (in CIREN).**
- **Truck occupants are less severely injured**
 - **ISS 16 vs. 24, $p = .006$.**
- **Occupants of trucks are more frequently injured in collisions with fixed objects than in collisions with cars.**
- **Lower extremities are the most commonly injured body region for truck occupants.**

Summary

- In side impacts between cars and trucks, car occupants fare worse.
- In frontal collisions, occupants of cars fare worse than occupants of trucks in collisions with heavy trucks, trees and other fixed objects.
- In our frontal collision cases, occupants of cars and trucks fare equally in collisions against both cars and trucks.
 - Limited sample
 - Differences in age, restraint use, crash severity
 - Changes in car frontal protection

